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ARMY INST OF DENTAL RESEARCH WASHINGTON DC
THE EFFECTS OF DIE RELIEF AGENT ON THE RETENTION OF FULL COVERA--ETC(U)
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REPORT DOCUMENTATION PAGE

INSTRUCTIONS
COMPLETING FORM
CATALOG NUMBER

1. REPORT NUMBER	2. GOVT ACCESSION NO.
AD-A095502	
4. TITLE (and Subtitle)	5. TYPE OF REPORT & PERIOD COVERED
6 The effects of die relief agent on the retention of full coverage castings	Manuscript
6. PERFORMING ORG. REPORT NUMBER	
8. CONTRACT OR GRANT NUMBER(s)	
10. PROGRAM ELEMENT, PROJECT, TASK AREA & WORK UNIT NUMBERS	
00-119 00-119-25	
12. REPORT DATE	
11/19 February 1981	
13. NUMBER OF PAGES	
13	
15. SECURITY CLASS. (of this report)	
Unclassified	
15a. DECLASSIFICATION/DOWNGRADING SCHEDULE	
16. DISTRIBUTION STATEMENT (of this Report)	
Unlimited	
17. DISTRIBUTION STATEMENT (of the abstract entered in Block 20, if different from Report)	
To be published in the <u>Journal of Prosthodontic Dentistry</u>	
18. SUPPLEMENTARY NOTES	
19. KEY WORDS (Continue on reverse side if necessary and identify by block number)	
Dental cements; die relief, casting accuracy and retention of castings.	
20. ABSTRACT (Continue on reverse side if necessary and identify by block number)	
The effect of the use of a proprietary die relief agent on the retention of castings cemented with zinc phosphate, a zinc polycarboxylate or a modified zinc oxide-eugenol cement was studied. Forces required to dislodge non-relieved castings from tooth preparations were significantly higher when zinc phosphate cement was the luting medium. The use of die relief agent resulted in a 32% reduction in the forces required to dislodge zinc phosphate-cemented castings. Data for the other luting media did not differ statistically. Correlation of these data with shear strength-tensile strength ratios of the cements indicate that the high shear strength afforded by zinc phosphate cement may be negated by	

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UNCLASSIFIED

SECURITY CLASSIFICATION OF THIS PAGE (When Data Entered)

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20. Abstract (Contd).

cementation of over size castings fabricated from dies coated with die relief agent.

The effects of die relief agent on the retention of full coverage castings.

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Commercial materials and equipment are identified in this report to specify the experimental procedure. Such identification does not imply official recommendation or endorsement or that the materials and equipment are necessarily the best available for the purpose. Furthermore, the opinions expressed herein are those of the authors and are not to be construed as those of the Army Medical Department.

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Clinically, the incomplete seating of cast restorations is not an infrequent observation. Attempts to improve seating of castings by internal adjustment at the time of cementation have proven largely unsuccessful and frustrating to the clinician. Several investigators¹⁻⁴ have demonstrated the influence of variations in technique on the seating and retention of castings. Internal acid etching, electromilling, venting and die relief have been shown to significantly improve the seating of cast restorations. At least one study⁴ has indicated that relieved crowns cemented with a zinc phosphate cement required 25% higher force for removal than unrelieved crowns.

The purpose of the present investigation was to assess the influence of die relief agent on the retention of castings cemented with three commonly employed luting media marketed for use in the final cementation of cast dental restorations.

MATERIALS AND METHODS

Eighteen freshly extracted human molars were stabilized in 0.75 inch diameter metal rings with the use of an autopolymerizing resin.* A diamond rotary instrument and a high speed dental handpiece using air-water coolant were employed to prepare the crown of each tooth to receive a full coverage cast restoration. Calculated taper of the walls of the prepared teeth ranged from 10 to 20 degrees. Chamfered cervical margins were developed and refined with fine finishing diamonds. Final polishing of the preparations was accomplished with flour of pumice and a wet rag-wheel.

*Fastray, Harry J. Bosworth Co., Skokie, IL 60076.

Individual acrylic resin* trays were fabricated and polysulfide elastomers⁺ were used in a simultaneous double mix injection technique to make duplicate impressions of each prepared tooth. The impressions were poured in an American Dental Association certified type IV dental stone.[#] Subsequent to removal from the impressions the walls of 18 of the dies were coated to within 0.5 mm of their cervical margins with a proprietary die-relief agent.[§] The material was applied in two 20-25 µm layers. The remaining 18 dies were retained in the non-relieved (unspaced) condition.

A conventional lost wax casting technique was employed to fabricate gold^Ω copings for the prepared teeth (Fig. 1). Casting was accomplished with the aid of a vacuum-pressure machine.[¶] Accordingly, each of 18 test components consisted of a prepared tooth, a spaced coping and an unspaced coping.

A table of random numbers was employed to select paired copings for cementation with a zinc phosphate cement,^{||} a polycarboxylate

*Fastray, Harry J. Bosworth Co., Skokie, IL 60067.

+Permlastic light body and heavy body impression material. Kerr Manufacturing Co., Romulus, MI 48174.

#Silky Rock, Whip Mix Corp., Louisville, KY 40217.

§Tru-Fit, George Taub Products, Jersey City, NJ 07306.

ΩMidas, J. F. Jelenko and Co., New Rochelle, NY 10801.

¶Chromatic System II, Whaledent International, New York, NY 10001.

||Fleck's Extraordinary Cement, Mizzy, Inc., Clifton Forge, VA 24422.

cement,** or a reinforced zinc oxide-eugenol cement.** The cements were proportioned and mixed in accordance with their respective manufacturer's instructions. Increments of freshly mixed cement were applied to the internal surfaces of the copings and the castings seated with finger pressure on the teeth for which they were fabricated. A static load was applied to the occlusal surface of each casting by means of a weighted lever calibrated to deliver a 5 Kg force. The load was maintained for 10 minutes at ambient laboratory conditions of temperature ($23^{\circ}\pm 2^{\circ}$ C) and relative humidity ($50\%\pm 10\%$). Then the test pieces were stored for 24 hours at 37° C and 100% relative humidity prior to further handling. Forces required to dislodge the castings were measured on a constant displacement rate testing machine## at a crosshead speed of 0.02 inch per minute. Self-aligning fixtures (Fig. 2) were employed to insure proper positioning of the specimens with respect to the direction of the applied forces.

After completion of each test run, gross remnants of cement were carefully removed from the teeth with hand instruments. Then the teeth were scrubbed in mild detergent, rinsed with distilled water and blotted dry. Cementation of the remaining member of the coping pair and storage of the specimens was accomplished by the procedures described previously. Six trials were made for each cement and each casting condition.

**Durelon, Premier Dental Products Co., Norristown, PA 19401.

++Fynal, The L. D. Caulk Co., Milford, DE 19963.

##Instron universal testing machine, Instron Engineering., Canton, MA 02021.

Values of the forces required to dislodge the cemented spaced and unspaced castings were evaluated statistically by analysis of variance and means compared using Scheffe's method at the 5% level of significance.

RESULTS

Mean values of the forces required to dislodge the castings are shown in the Table. The range of forces required for separation of the cemented crown-tooth assemblies were delineated by spaced castings luted with Durelon (18 Kg) and unspaced castings luted with Fleck's cement (37 Kg). Analysis of the data revealed significant differences in retention of the cast copings relating to cements ($0.001 < p < 0.005$) and the use of a die relief agent ($0.025 < p < 0.05$). Comparison of mean force values indicated that unspaced castings cemented with Fleck's cement required significantly more force for removal than those cemented with either Durelon or Fynal. When the die relief agent was employed, the mean force values for the cements did not differ statistically. However, the use of die relief agent resulted in a significant 32% reduction in the amount of force required to dislodge the copings when Fleck's cement was the luting medium.

Examination of the surfaces of the preparations and castings following failure revealed that specimens cemented with either Fynal or Durelon failed adhesively at the cement-dentin phase boundary; whereas, those cemented with Fleck's cement exhibited a mixed (adhesive-cohesive) mode of failure. The die relief agent did not appear to influence the mode of failure of the luting medium.

DISCUSSION

The amount of retention exhibited by cast restorations is influenced by several factors. Preparation design, casting accuracy and the physical and mechanical characteristics of the luting medium play prominent roles in the maintenance of the integrity of casting-tooth couples. The relatively high coefficients of variation of the data reflect the random effects of these factors.

The observation of higher retention values for unspaced castings luted with the zinc phosphate cement and the modes of failure of the luting media differ from those of other investigators. Previous studies have reported equal retention values for zinc phosphate and zinc polycarboxylate cements and a mixed mode (adhesive-cohesive) failure of the polycarboxylate materials.⁵

The significant reduction in the amount of force required to dislodge spaced castings cemented with Fleck's cement may reflect the predominance of different forces within the cement films under each casting condition. Correlation of these data with shear strength-tensile strength ratios of Fleck's (6.0:1), Durelon (2.2:1) and Fynal (1.7:1)⁶ suggests that failure of relatively thin films of zinc phosphate cement occurs mainly as a result of shear forces. On the other hand, the failure of thicker films appears to be initiated by tensile forces. The similarity of force values required to remove spaced and unspaced castings cemented with the other two cements may reflect the relative similarity of their respective shear strength-tensile strength ratios to unity.

Criteria for the selection of a specific luting agent for clinical use are manifold. The biological requirements of the individual case are the primary considerations.⁷ Secondly, however, are factors related to the tooth preparation and the properties of the luting medium. Studies^{8,9} have indicated that no differences exist between the retentive abilities of modified zinc oxide-eugenol, zinc polyacrylate or zinc phosphate cement when used to retain crowns on preparations exhibiting good retention form. However, preparations exhibiting minimal retention form require the high strength of a zinc phosphate cement to maximize casting retention.¹⁰ From the data, it would appear that the advantage of high shear strength afforded by zinc phosphate cement is compromised severely in the cementation of oversize full coverage castings.

SUMMARY

The effect of the use of a proprietary die relief agent on the retention of castings cemented with a zinc phosphate, a zinc polycarboxylate or a modified zinc oxide-eugenol cement was studied. Forces required to dislodge non-relieved castings from tooth preparations were significantly higher when zinc phosphate cement was the luting medium. The use of die relief agent resulted in a 32% reduction in the forces required to dislodge zinc phosphate-cemented castings. Data for the other luting media did not differ statistically. Correlation of these data with shear strength-tensile strength ratios of the cements indicate that the high shear strength afforded by zinc phosphate cement may be negated by cementation of over size castings fabricated from dies coated with die relief agent.

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Table. Forces (in kilograms) required to dislodge cemented castings

Luting	Casting Condition					
	Unspaced			Spaced		
	\bar{x}	SD	CV*	\bar{x}	SD	CV*
Zinc phosphate cement	37	5	14%	25	9	36%
Polycarboxylate cement	22	7	32%	18	6	30%
Modified zinc-oxide eugenol cement	23	6	26%	23	7	30%

*Coefficient of variation.

Scheffe' allowances at the 5% level of significance were computed to be 11 Kg for materials and 7 Kg for the casting condition respectively.

LEGENDS FOR FIGURES

Figure 1. Tooth-coping assembly with integral cast occlusal loop.

Figure 2. Cross-sectional diagram of self-aligning fixtures used during coping removal.





